This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

551.4
M653

From Chas W Foote

J. C. Branner

NOTES

UPON THE

Geological History

—OF—

Cayuga and Seneca Lakes,

TOGETHER WITH A

Few General Remarks upon the Glacial Period.

By CHARLES W. FOOTE, A. M.

ITHACA, N. Y.:
NORTON & CONKLIN, POWER PRESS PRINTERS.
1877.

551.4
N65

The Branner Geological Library

LELAND·STANFORD·JVNIOR·VNIVERSITY

COMPLIMENTS
OF THE AUTHOR.

NOTES UPON THE
Geological History of Cayuga and Seneca Lakes;
TOGETHER WITH A FEW GENERAL REMARKS UPON THE GLACIAL PERIOD.

Thesis presented for the degree of Doctor of Philosophy, at Cornell University, June, 1878.]

BY CHARLES W. FOOTE, A. M.

That a number of changes of relative level of sea and land have ccurred during past ages, is undoubted. That secular variations the kind are now in progress is also beyond question. While ssibly such differences may be in part due to modifications of the a-bottom with sequent change of absolute water-level, there is ason to believe that most of them have been produced by oscillaons of considerable areas of land-surfaces. The uplifting of the ncinnati geanticlinal and the Green Mts. at the close of the Lower lurian; of the Appalachian system at the close of the Paleozoic; nchronously with this also the first great epoch of elevation of a ortion of the Rocky Mts., a second toward the end of the Triassic, a ird at close of the Cretaceous, and the fourth during the Tertiary;[a.] f the Wahsatch and Uintah ranges the latter part of the Jurassic;[b.] f the Pyrenees after the Middle Eocene, and the Alps during the iocene and Pliocene, may be instanced as examples. Inland bodies f water—lakes, rivers and the smaller streams—must have been uch more strongly affected by disturbances which involved their wn and neighboring districts. Those portions of the interior coninental basin bordering upon our present system of great lakes merged from beneath a shallow sea during the latter part of the evonian or early in the Carboniferous Age, since which time they ave been continuously free from marine invasion.

As the surface-contour is of course more largely dependent pon the effects of the Glacial and subsequent periods, it is with hese geologically recent times and especially in the neighborhood f Cayuga and Seneca lakes that we are in the present paper chiefly oncerned. Without here entering upon a lengthy discussion as to

[For a record of the periods of elevation within this state, see the Natural History f New York, Part II. Geology, by Prof. W. M. Mather, pp. 628,629.]

[a.] Lt. Wheeler's Rep. Surv. West of 100th Mer. Vol. III, 1875, pp. 499, 500, 501.

[b.] Clarence King's Rep. Surv. of 40th Par. Lat. Vol. III, 1870, pp. 452-453.

245288

whether the glacier or iceberg theory is the more probable or bett accounts for the well-known phenomena referred by all alike to th Glacial Period, I will at the outset enunciate my own opinion, th both agencies have been employed, and that the glacier preced the immense floating masses and produced the greater effect. M reasons for such belief are embodied in the following pages.

The general conformation of the surface of this vicinity, I believ to have been determined previous to the commencement of the gl cial movement and during the slow emergence of the land from a enveloping ocean. The appearance of the hill-tops, with the marke parallelism of intervening valleys, would indicate erosive action o waves rather than of currents. The language of Dr. Edward Hitch cock aptly describes, and at the same time suggests an explanation o just such cases: "If the crest of a mountain is crossed by paralle valleys of different heights, evidently eroded, the presumption i that the deundation was accomplished mainly by oceanic action, by the flux and reflux waves and tides during the upheaval of the land."[a]

As the land gradually rose, the water draining off the northern surface of the country eroded those fiords characteristic of upper latitudes, and which afford proof of the believed elevation. Such I conceive to have been the origin of many of the valleys which are now occupied by the numerous north and south lakes of central New York.

There is abundant evidence that at some epoch of the past there has been a vast and powerful current from the head of Lake Michigan, southward across Illinois. As is stated by Prof. F. H. Bradley, who has given this subject much time and study: "Whether there was or not an outlet from the south end of Lake Michigan after the close of the Drift Period, there certainly was one at that point before the drift was deposited." [b]

The bottom of this channel was about 200 ft. below the present level of the lake.

The famous "Pictured Rocks" of Lake Superior, are of Silurian age, from 50 to 200 ft. high, and show beyond a doubt that they were eroded by the action of a body of water. [c]

From Lake Superior east of the Pictured Rocks across to Lake higan appears to be a great depth of sand and gravel entirely from rocks *in situ*.

---

[a] Article in Vol. IX, 1857, Smithson. Contrib. to Knowledge, p. 68.

[b] Geol. Surv. Ill. Vol. IV, 1870, p. 229.

[c] " " Mich., Vol. 1, 1873, p. 68.

The city of Detroit is 130 ft. above solid rock, while upon the nadian side of the river the overlying clay is from 50 to 200 ft. depth.

Mr. G. K. Gilbert, who has made a similar study of the west of Lake Erie, concludes that it likewise had a southwest commu- ation with the interior sea, following closely the course now cov- d by the Maumee River, very far below its existing level and at epth equal to that of the outlet from Lake Michigan. Borings Toledo indicate that the ancient bed of the river was at least 140 (probably somewhat more) below its present level. Nearly all rivers now emptying into Lake Erie flow over beds very much her than those once occupied by them, the ancient channels being v silted up with drift material. So at Cleveland a former bed of Cuyahoga River was 230 ft. lower than now. [a]

At New Philadelphia, Ohio, the Tuscarawas River is running ft. above its ancient channel. The Ohio follows very close- an old course nowhere less than 150 ft. below the present river. ny other instances of a like character might also be cited, but are necessary. Dr. Newberry thus sums up: "The lake region [ear- in the Glacial Period] in common with all the northern portion of American Continent, was raised several thousand feet above the el of the sea. During this period Lake Erie did not exist as a e but as a valley traversed by a river to which the Cuyahoga, rmillion, Chagrin, &c., were tributaries." [b]

It is quite possible that these excavations were accomplished in t by icebergs from the north, but by far the larger portion was e simply to erosion by fresh water. Prof. Hilgard in his "Report ncerning the Mississippi Delta," cites evidence to the effect that whole region thereabout was, early in the Drift Period, at least 0 ft. higher than now; that the "Father-of-Waters" virtually tra- sed the same course then as now, with only a vertical difference altitude. These and many similar data which might be adduced nish conclusive evidence that the entire system of interior con- ental drainage at that time was almost an archetype of the present.

Passing eastward we notice first the former and much straight- gorge of the Genesee River at and above Portage now completely filled with drift. Prof. James Hall speaks of this at length in his "Report upon the Geology of New York," and co ers it of very ancient origin as compared with the present cha and that it was excavated by a powerful current and in a com tively short time.[a]

---

[a] Geol. Surv. Ohio, Vol II, 1874, p. 15.

[b] Proc. Boston Soc. Nat. Hist. May, 1862, p. 5. A.

Nearly all the many lakes of central New York occupy are in reality the bottoms of deep ravines, and their notable par ism in a general north and south direction has been the subjec frequent comment.

Below are the present surface levels and depths of severa accurately as I am able to obtain the figures:

	Elevation above tide.	Depth.	Height of present bottom.
Canandaigua	668 feet.	Shallow.	———
Crooked (Keuka)	718 "	200 feet.	500 feet.
Seneca	438 "	530 "	-100 "
Cayuga	375 "	425 "	-50 "
Owasco	705 "	Shallow.	———
Skaneateles	860 "	320 feet.	540 "
Onondaga	369 "	65 "	300 "

A glance shows the great differences between Seneca and yuga lakes and the others, both as to absolute elevation (excep only Onondaga) and depression of the bottom. Lake Erie a deepest only reaches a point 250 ft. *above* tide-level; Lake Ont descends to just about ocean-level, while Lakes Michigan, Hu and Superior vary from 300 to 400 ft. *below*. Thus by compar we see that these narrow lakes—Seneca and Cayuga—nowhere three or four miles in breadth, occupy gorges which pierce earth's crust to an almost equal depth with the greatest lakes. present bottoms (which must have been more or less elevated by deposition of detritus) being considerably below that of Lake C rio, also indicates that the flow of water was toward the so The valleys of both are plainly continued, to the south through ridge of high land, connecting with the Susquehanna; to the n into Ontario by channels now drift-filled. Says Prof. Hall: the time when the water of this lake or bay [the great interior was at a higher elevation, it doubtless communicated with the leys of Seneca and Cayuga lakes, and even discharged south through these valleys."[b] The present outlet of both—the Se River—abruptly turning a right angle to the trend of the lak evidently modern and wholly post-glacial.

---

a. N. Y. Rep. Geol. Part IV., pp. 343, 344 and 372.

b. N. Y. Nat. Hist. Part IV, p. 349.

The present contours of several of these valleys are indicated y the following heights:

From Seneca Lake southward to Elmira (17 1-2 miles) viz.: ke-level 438 ft.; Havana 453 ft.; Millport 743 ft.; highest level the Chemung Canal at Horseheads 884 ft.; Elmira 862 ft.

From Cayuga lake southward to Waverly (25 miles), viz: Itha- 405 ft.; highest bed of the valley about 12 miles below Ithaca, 25 ft.; Spencer 6 miles beyond, 985 ft.; Waverly 836 ft.

Or, by another valley to the southeast: Ithaca 405 ft.; summit ear Caroline Station 970 ft.; Willseyville 913 ft.; Owego on the usquehanna, 795 ft.[a] Of these last two we will speak more fully rther on.

Also, from Auburn 646 ft.; Owasco lake 705 ft.; Dryden 79 ft.; Harford 1208 ft.; Richford 1090 ft.; to Owego, 808 ft.[b]

Syracuse 385 ft.; Jamesville 595 ft.; Tully 1247 ft.; Lisle 965 t.; Binghamton 852 ft.

It must be borne in mind that the highest land of each of these alleys is still several hundreds of feet below the bordering hills nd country. Of Broome Co. (and the same with almost qual force might have been predicated of Tioga, Chemung, Tompins and other neighboring counties) Prof. Vanuxem said that the road and deep valleys through which flow the Susquehanna and ther rivers are valleys of excavation, by their breadth and depth xhibiting the greatness of the action of water.[c]

Onondaga Lake, near Syracuse, fills a slight hollow in an extenled north and south tract of alluvion of very great depth. Hon. eo. Geddes describes a boring in the centre of this tract which did ot strike rock until at a depth of 414 ft., 53 ft. below sea level.[d]

But erosion is best exhibited and in its greatest effect, in the alley extending from near the foot of Lake Ontario eastwardly and ltimately reaching the Hudson River, in which are situated Oneida ake and the Mohawk River, upon a bed of drift of considerable epth. Nearly all authorities are agreed in considering this a valley f excavation chiefly and cut by running water. Several theories ave been advanced to account for it. In some points these generlly coincide, e. g., that: (1) the work was accomplished mainly by ater; (2) the direction was from west to east; (3) it was apparent-

---

a. D. L. & W. R. R. Survey.

b. Southern Central R. R. Survey.

c. N. Y. Rep. Part III, Geology, p. 294.

d. N. Y. State Agric'l Rep. 1859, p. 278.

ly effected in a comparatively short time; (4) it must have been cut prior to the deposition of the now superincumbent drift. Prof. Dana however to some extent dissents from the first of these propositions. In an article concerning the Mohawk Valley, he says[a] "that it is *not* a valley of denudation, although beyond doubt greatly deepened and extended by the action of waters;" "that it is a *geoclinal* valley, *i. e.* one formed by the uplift of the crust of the earth on either side (or else by the depression of the crust along its course) without any conformity to its slopes in the dip of the enclosing rocks." The letter of Rev. W. B. Dwight, which is introduced by Prof. Dana and which forms the major part of the article, sums up as follows: "The best conclusions that I can gather from these facts [relative to rock scorings] are that there are two systems of scratches in that part of the State at right angles nearly to each other; that one system corresponds with the general direction of the great valleys running southerly, and that the other system corresponds with the direction of the Mohawk Valley, although where I have observed it there is no modern valley in the immediate vicinity to correspond to it." Prof. Dana appends: "These conclusions of Mr. Dwight appear to be altogether just." It is with great diffidence that the writer ventures to differ with these gentlemen. I am however strongly of the opinion that the greater portion of the erosion was caused in a manner similar to that which I have considered to be the mode of production of the basins of Seneca and Cayuga lakes, *i. e.* by the drainage of the vast inland sea early in Quarternary time while the land of the upper latitudes was in process of elevation. Dr. Newberry, in his "Report upon the Ohio Survey" says that before the Glacial Period the whole northern part of the continent was elevated considerably higher than now and was drained by a much lower river system; that at that time Lakes Huron, Erie, and Ontario apparently formed portions of the valley of a river which subsequently became the St. Lawrence, but which then flowed between the Adirondacks and Appalachians, in the line of the deeply drift-buried channel of the Mohawk; that Lake Michigan was also then a part of a river course which drained Lake Superior, discharging into the Mississippi, the straits of Mackinaw not yet being opened.[b]

In an old sketch describing the boundaries of the Great St.

---

[a] Am. Jour. Science. Vol. XXXV, 1863, p. 243, et. seq.

[b] Geol. Surv. Ohio, Vol. II, 1874, p. 77.

wrence Basin, David H. Burr wrote: "Beginning near the eastern
tremity of Lake Erie, the boundary or edge of the basin may be
ced on the map along the heads of streams flowing into Lake
tario through the southern part of the counties of Erie and
nesee to the valley of the Genesee River, which is an arm of the
sin stretching up into the highlands of Pa. From the Genesee
ver the edge of the basin curves to the southeast around the
uthern extremities of Seneca and Cayuga lakes, occupying deep
vines which may also be considered as arms or branches of the
incipal basin, separated from each other by a ridge of 1200 ft.
ight above the ocean. From the head of Cayuga Lake the edge
the basin turns suddenly to the north along the lake and passes
a northeasterly direction through the northern part of Cortland
ounty, a little south of Skaneateles Lake in nearly a straight
e to Little Falls on the Mohawk River. Here it suffers for the
st time in the course we have described, an interruption, and an
tlet appears to have been forcibly broken through by some tre-
endous convulsion of Nature. * * * The lowest pass from
e ocean into the great depression of the St. Lawrence Basin
roughout its whole extent (except the bed of the St. Lawrence
iver) is through the valleys of the Hudson and Mohawk rivers.
he highest part of this pass is near Little Falls, and is elevated only
5 ft. above the level of tide water. The *next* lowest pass is
uth of Lake Michigan, and is about 700 ft. above the ocean. The
west pass south of Lake Erie is on the line of the Ohio canal, and
400 ft. above the lake, or nearly 1,000 ft. higher than the ocean.
his statement is incorrect: the lowest pass lies between the Wa-
sh and Maumee rivers, and is 810 ft. only above the ocean. *Vide*
etch by Col. Chas. Whittlesey accompanying Walling and Gray's
opographical Atlas of Ohio, 1872. C.W. F.] The lowest pass from
ntario to the south is through the valley extending from the head
Seneca lake to Elmira on the Chemung River, the summit of
hich is elevated 885 ft. above tide water. From these data we
ay infer a curious fact, that if a sufficient barrier were to exist
ross the St. Lawrence River near Quebec, and another at Little
alls on the Mohawk, Lake Ontario would rise to the level of Lake
perior, and the five great western lakes would be merged in one
mense inland sea. That this has actually been the state of things
some remote period in the history of our globe is a favorite opin-
n of many; and indeed the appearance of the two outlets, partic-
arly that at Little Falls, and the nature of the surface of the differ-

ent slopes of the whole basin, are not unfavorable to the support this hypothesis. * * * At Little Falls the river (the Mohaw descends through a narrow pass to the lower valley, and offers i contestable evidence of having forcibly *broken through* the primiti rock; the ledges on each side bear striking marks of the action water up to considerable heights above the present level of t stream." [a]

Also, Prof. Vanuxem: "In the dip of the general disposition the line of division or layers of the gneiss rock, which is to the e and north, we find a ready solution of the cause of its destruction the Noses and Little Falls. The ends of the layers being present to the current, parts were readily torn up and washed away by t hold which they gave to the water, and time was given for th destruction; but had the dip been in the opposite direction, it equally obvious that no effect of the kind could have taken pl the Noses and Little Falls would have been barriers to the waters the Mohawk to this day." [b] I have cited thus at considerable leng because the authors have presented quite a number of points in co nection with the valley which I had myself intended to offer. Fro a personal and somewhat careful observation of the place, I wou earnestly concur in the above remarks as to the *forcibly water-wo* appearance of the gap at Little Falls. While I do not doubt t former presence of glacial ice—(I have seen deeply chiselled furro upon the top of the ledges upon the south side of the Mohawk this point, coinciding exactly with the direction of the valley, a which, it seemed to me, could be ascribed to no other agency)- yet the deep and narrow gorge, the peculiarly rounded knobs a projections, the almost entire absence of foreign boulders, &c., & all point to *running water* as the principal effective agent.

The elevation of the land was undoubtedly very gradual, as w also the diminution of temperature occasioned by and accompanying i The immense masses of ice continually encroaching southward, bo by reason of the descent of the snow-line and by its peculiar mole lar motion, finally reached the point at which no further increme could be added upon the front because of the warmer climate. Th upheaving of the land at last having ceased, it is highly probab that a stationary period of greater or less duration ensued, durin which however the glacier maintained its own onward molecul

---

a. Old Atlas of New York State, 1829.

b. N. Y. Geol. Rep., 1838, p. 262.

movement, transporting débris, pushing forward the attritus of its sides and bottom, and heaping up its moraines. It was during the time so far elapsed that occurred most of the ploughing, grinding and scoring of the subjacent rocks, pulverizing them into the material recognized as the "drift," and now constituting the major portion of the soil. Finally, as the land began subsiding again, the climate becoming less rigorous, an exact reverse of the preceding took place; the glacier retreated, dropping its burden of stones, pebbles, and detritus, while, issuing from its base, the stream formed by its melting distributed these over the near country. During the period of most arctic temperature, it is probable that one enormous and unbroken ice-sheet from the north and northwest moved over the entire surface of land east of the Mississippi River (excepting a small portion of Wisconsin and Illinois,) down to the 39th or 40th parallel of latitude, producing those gravings now seen especially upon the higher eminences of the lake region and in New England. The thickness of this has been until recently closely estimated from the belief that Mt. Washington, alone of all elevations within the region, reared its head above the enveloping mass. But during the summer of 1875, Prof. C. H. Hitchcock made a more careful investigation and found that even *its* summit, 6293 ft. above tide-level, had not escaped the common covering.[a] Thus we now seem absolutely without data from which to form any judgment of its vertical height.

The flow of this continental ice-sheet was determined more or less by the previously existing channels. These, filled, controlled the direction of movement, and thus we notice that everywhere the principal scarification corresponds with the chief neighboring valleys.

As the *mer-de-glace* withdrew northward, its terminal moraines dammed these early established and more lately ice-deepened valleys of drainage, so that by its melting ponds of fresh water enlarged upon its lower margin, eventually uniting into one vast inland sea. Large bodies of ice were also by its retreat left isolated in lateral depressions; these slowly worked down into the principal basins (as it has been demonstrated time and again that ice will descend a declivity inappreciable to the eye, its own weight furnishing an amply sufficient *vis a tergo*) and so formed tributary valleys. In this manner, it seems to me, originated the glacier of the Mohawk Valley, of no great volume comparatively, and productive of but slight effects, creeping down the very gentle decline of the "Great Level" and beyond eastward.

---

[a] Proc. Am. Assoc. for Adv. of Science, 1875, p. 93.

This first great sheet of ice was in all probability the active agency in excavating the beds of Lakes Huron and Michigan, and the eastern portion of Superior. Sir. W. E. Logan says: "On Lake Superior the general direction of the striae is southward. * * * These great lake basins are depressions, not of geological structure, but of denudation; and the grooves on the surfaces of the rocks, which descend under the water, appear to point to glacial action as one of the great causes which have produced these depressions." Also, "On Lake Huron, as on Lake Superior, the general direction of the striae is south varying only a few degrees to the east or west." [a] Dr. Rominger in his "Report upon the Upper Peninsula" of Michigan writes; "All these scratches point in one constant direction from which the force acted, and which varies little from a north and south direction."[b] The bed of Lake Michigan was caused in a similar manner. The almost innumerable round-topped islands of granite (estimated by Captain Bayfield at 30,000) completely filling the Sault Ste. Marie and upper portion of Lake Huron, exemplify in a most vivid manner the *roches moutonnées* of glacial production.

In one of the publications of the Ohio Survey occurs the following: "The direction of the glacial furrows proves that one of these ice rivers flowed from Lake Huron along the channel now filled with drift and known to be at least 150 ft. deep, into Lake Erie, which &c."[c]

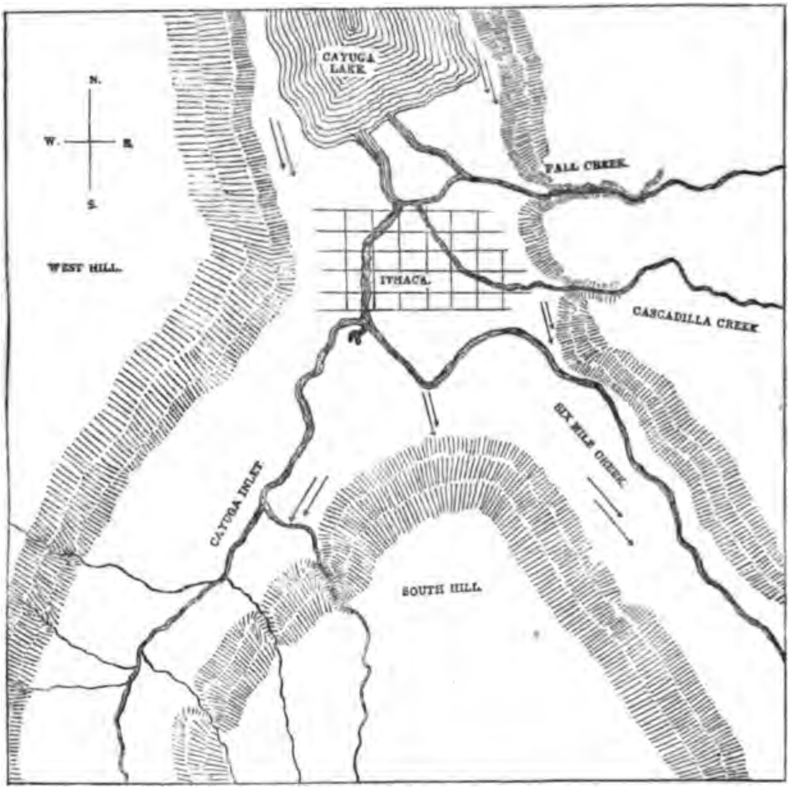
The beds of Seneca and Cayuga Lakes were probably much deepened by the gouging action of the lobes of the general ice-sheet which flowed down their channels. About the head of Cayuga Lake, at Ithaca, the abundant scorings show that the glacier, impinging upon the mass of Chemung shale which constitutes South Hill, was split into two portions, one of which–the lesser–followed the present valley of Six-Mile Creek as far at least as Mott's Corners (7 miles); the other was deflected to the right and proceeded up the basin of the Inlet. An outline sketch of the vicinity is shown opposite, with the directions and a few of the localities of glacial markings indicated.

---

[a] Geol. of Canada, 1863. pp. 888 and 889,

[b] Mich. Survey, Vol. I, 1873, p. 15.

[c] Report of Progress, 1869, p. 28.



MAP OF THE HEAD OF CAYUGA LAKE AND VICINITY, WITH THE GENERAL BEARINGS AND SOME OF THE LOCALITIES OF GLACIAL SCORINGS INDICATED.

Six Mile Creek and the Inlet clearly evidence the effects of glacial action, while the lower portions of Fall Creek and Cascadilla are wholly post-glacial. Several lake-terraces at different heights are plainly discernible upon both sides of the valleys; these are especially well exhibited at the Devil's Glen, a mile southwest of Ithaca, where no less than five benches are distinctly seen, across and down through all of which the stream has worn its way as the lake-surface has successively fallen to lower levels. By the icebergs which floated southward upon the cold fresh-water sea, very many boulders were transported from their native localities greater or less distances, and distributed over the bottom wherever the berg happened to strand or melt. Such are now found very commonly in this section. A boulder of the Tully limestone (the nearest outcrop of which is about four miles down the lake), very much worn and scratched, probably having been also pushed somewhat by the glacier, is to be seen in a cutting of the Utica, Ithaca and Elmira R. R., a little east of the depot.

I might easily refer to numerous similarly transported blocks in this vicinity but these few will as well suffice. These many boulders resting upon the drift must have been floated and let fall after the drift was deposited. Lying as they now do at all heights, they afford another proof of former greater altitudes of the lake.

Blocks from the Hamilton and Oriskany groups (neither of which occurs *in situ* within several miles to the northward) are also frequently seen scattered over the surface. A very large mass of the Tully lies a few feet beneath the surface in the valley, thirteen miles south of Ithaca; the workmen were obliged to blast a cutting through it in constructing the Geneva, Ithaca and Sayre R. R.; its thickness is not known.

It is worthy of notice that the general direction of the principal streams of Tompkins County is still toward the south. This is well shown in the case of Ludlowville Creek. It scarcely varies from an exact southerly bearing, till within a mile of its mouth it makes almost a right-angle, turning toward the lake. While the lake stood at a much higher level, the creek seems to have emptied into it, toward the south and at a very acute inclination to its eastern shore, in the neighborhood of the bend referred to. At this same time Fall Creek discharged at a point east and north of its later-cut cañon, also toward the south.

The configuration of the ancient valleys and stream-courses appears to indicate that the outlet of the lake was then southward.

When in process of time the barrier at the north was removed, the surface gradually fell, the current changed about and began to bank up the detritus brought down by each stream before its *embouchure* so that its mouth slowly worked backward and northward. Thus Fall Creek began excavating the gorge of its lower portion ; then first came into existence following the retreating lake, Cascadilla and Six-Mile creeks, Buttermilk, Lick-Brook and Enfield (whose flood-portion constitutes Cayuga Inlet) and the lesser creeks of the western valley.

Cortland County (the next east of Tompkins), with the exception of a small portion which contributes to Fall Creek, is now drained to the south by the Tioghnioga River.

As before remarked, succeeding the aeons of most intense cold there ensued a depression of the land and a warmer climate, abbreviating the ice-mass and flooding the great interior basin. This, I believe, was again changed to a period of elevation and consequent reduction of temperature during which was formed the St. Lawrence glacier which proceeded *up* the valley of that river. As to the latter point I quote: "Dr. Bigsby long since observed that the boulders of dolerite derived from Mt. Montreal have been drifted principally *to the southwestward*, in which direction they are said to have been traced for a distance of 270 miles, to the south shore of Lake Ontario, marking the direction of the ancient currents or glaciers as having been from the northeast."[a]

Dr. J. W. Dawson (who believes that the scorings were due to *ice-berg* rather than to *glacial* action) wrote : "It would seem that the dominant direction of the striae in the valley of the St. Lawrence is northeast and southwest ; * * * I have no hesitation in asserting from my own observations as well as from those of others, that for the southwest striation, the direction was *from the ocean toward the interior against the slope of the St. Lawrence Valley.* The crag-and-tail forms of all our isolated hills and the direction of transport of boulders carried from them, show that throughout Canada the movement was from northeast to southwest." [b] Also in the *Canadian Naturalist:* "I have already noticed the striation on rock-surfaces at Montreal and may merely add that it is often very perfect and must have been produced by a force acting up the St. Lawrence Valley from the northeast." [a]

---

[a] Geol. of Canada, p. 918.

[b] Acadian Geology, p. 69.

Prof. J. Milne, in an article upon "Ice and Ice-work in Newfoundland" in the *Geological Magazine*, spoke at some length of the striking conformity in the direction of its principal bays, its mountains, lakes, rivers, lines of igneous protrusions, its ice-grooves and scratches, and other features of geological interest—all trending from about 27° east of north to 27° west of south. He also believes that the ice-markings were made by glaciers rather than by floating ice.

Dr. A. S. Packard, Jr., refers to the above article as corroborative of his own conclusions from two summers' travels along the coast of Labrador.[b]

Dr. Newberry seems inclined to a similar view as to variations of temperature during the Pleistocene, for he says: "We may also find records here, as some geologists do in Europe, of great alternations of climate in the immensely long Quaternary Age"[c]; and again: "In the Old World distinct traces are found of a return of arctic conditions after the first great glaciers had melted away, and a milder climate had supervened. In this country we have not yet detected any certain proof of the return of the glaciers to the area which they had before occupied and abandoned, although in southern Ohio the sheet of pebbly clay which overlies the Forest Bed seems to indicate a return in that region of something like the condition in which the first boulder clay was deposited." [d]

This St. Lawrence glacier after passing over the very hard belt of Archæan gneiss which unites the Adirondack Mts. with the Laurentian Range and affords a barrier to the waters of Lake Ontario, ploughed deeply into the soft, little resisting beds of shale and limestone to the south of it, removing the superimposed rock to the depth of the harder Trenton limestone.

The basin of Lake Erie was in all probability excavated by the same glacier; cutting through the intervening Middle and Upper Silurian escarpment somewhere in Canada not far west of the Niagara River, it encountered the readily yielding Devonian shales and expended its now much-enfeebled energy in overcoming these obstacles. There is evidence that the eastern portion of the basin was cut much more deeply than the western; the force was rapidly declining. During the second epoch of cold, the former channels were again occupied by local ice-rivers but far inferior to the earlier continental sheet. At this time also very probably were caused the western and larger expansion of Lake Superior[a] and many of the side-extensions of Lakes Michigan and Huron, such as Green Bay, the Straits of Mackinaw,[b] Saginaw Bay, Straits of Manitoulin and Georgian Bay.[c] In these the trend of the striae accords more nearly with a general northeast and southwest direction; they are also shallower than the main bodies of the lakes.

---

[a] Vol. VI. No. III, March, 1872.
[b] Amer. Naturalist, Nov. 1876.
[c] Geol. Surv. Ohio, Vol. II, 1874, p. 79.
[d] " " " " " " " 8.

When the southern extremity of the last glacier began melting, a re-occurrence of the former series of conditions ensued. The inland fresh-water sea again accumulated; icebergs floated southward upon it, bringing great loads of débris; the water was prevented by the slowly dissolving ice-mass from escaping toward the north and northeast.

Together with this occurred a great depression of the same northern part of the continent, ushering in the Champlain Epoch and continuing until the ocean waters almost or quite reached the great lake.

Again the oscillation changed and a final and probably still-progressing upward motion succeeded; gradually the lake-surface was lowered by means of the ancient waste-weirs flowing above and through the drift-masses which had choked them; the lapse of time had however been sufficient to permit the formation at various heights of those several terraces which are so distinctly traceable around the entire basin.

So long as no change of present conditions shall occur, the depth of the Great Lakes will be constantly lessening, both because of sedimentary deposits (which are quite *rapidly* affecting the western half of Lake Erie), and by the slow detrition of their respective barriers.

---

[a] In an article by Col. Chas. Whittlesey upon "The Fresh Water Glacial Drift of the Northern States" in Vol. XV., Smithso. Contrib. to Knowledge occurs the following: "The western half of Lake Superior occupies a synclinal basin in the Potsdam sandstone, and its long axis coincides with the glacier movement precisely." p. 32.

[b] "In the Straits of Mackinaw the movement was from east to west." Ibid. p. 31.

[c] Geol. of Canada. p. 891. "Striae, S. 37° W. and S. 45° W."

RARY

returned on
d below.

Gaylord Bros,
Makers
Syracuse, N. Y.
PAT. JAN. 21, 1908

557.4 .N65f C.1
Notes upon the geological hist
Stanford University Libraries
3 6105 032 180 320

2452